A robust high-order finite volume method for advection on geodesic spherical grids.

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Abstract

The sphere is commonly used as a computational domain to represent the planet Earth. In this way, it is possible to model several physical phenomena, such as the numerical weather forecast. Discretization can be done in different ways, but due to an increasing need for computational efficiency, geodesic meshes have gained the attention of the scientific community. These are more isotropic in relation to the latitude / longitude meshes, among which, the icosahedral meshes stand out. The quality of weather forecast models is strongly influenced by the accuracy of the solution of the advection (or transport) equation, since it is necessary to evaluate the transport of various substances present in the atmosphere. In this context, researchers have been interested in developing high-order methods on the sphere to improve the quality of the scalar transport solution. Although there are some high order numerical models that use icosahedral meshes, there is no consensus on the methodologies and types of meshes to be used. The objective of this work was to study the methods available in the literature and to propose a new high order method in the sphere, based on the works of Ollivier-Gooch et al. The finite-order finite-volume method was validated with interpolation, integration and discretization tests of the divergent. For this purpose, several tests were used for the advection and the results were compared with those from the literature for icosahedral meshes with different optimizations. The tests include smooth functions, with discontinuities and tests of deformations in the distribution of the transported field, which are fundamental in the development of global atmospheric models. The numerical results show that the proposed method, which will be called FV-OLG, was able to obtain a high order of accuracy and verified that the error rates are little influenced by mesh distortion. An additional test was carried out to evaluate the transport of a Gaussian hill in the icosahedral grid with local refinement. The results show that the convergence rates are the same as those obtained in meshes with different optimizations, demonstrating that it is a robust method to be used in global atmospheric models.

Keywords: High order methods, Advection equation, Icosahedral grid, Finite volumes

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